A Study of the Presence or Absence of Nitrogen Bands in the Auroral Spectrum.

By Lord Rayleigh, F.R.S.

(Received April 24, 1922.)

In a previous paper* I showed that the negative bands of nitrogen were actually stronger than the green aurora line on the occasion of the auroral display of May 13–14, 1921, which was a typical aurora, in the sense that it was accompanied by conspicuous solar and magnetic disturbance. In contrast with this, the nitrogen bands were not observed at all in the numerous photographs which showed the green line in the night sky on ordinary nights in the south of England.† The point deserved much closer scrutiny, as it might be expected to throw light on whether the ordinary night sky effect was to be classed with the northern lights or not.

To get additional evidence, I proceeded to Shetland in mid-October, 1921. Dr. G. C. Simpson, F.R.S., and Dr. A. Crichton Mitchell very kindly gave me facilities for working at the meteorological observatory near Lerwick, and Mr. J. Crichton, the officer in charge, did everything possible to help, and continued the exposures throughout the winter after I had left. Indeed, all the most successful photographs were taken by him, and forwarded to me for discussion.

The northern lights were several times seen, but, in view of the apparently considerable visual intensity, I was surprised to find how faintly the green line came out with a pocket spectroscope, or on the photographic spectra. I suspect that much of the light is continuous background, which is lost when spread out by the prism.

There is some confirmation in observations with colour filters. Thus, on October 21 there was a bright auroral arch in the north, extending to an altitude of about 30°. It was visible through the orange Wratten filter No. 23, which cuts out the green aurora line. On the other hand, it was not visible through the red filter No. 29, which transmits the red aurora line. It must therefore come from a region of the spectrum between the green and red lines, and since no auroral line is well established to exist in this region, the light is probably to be referred to a continuous background of the spectrum.

The changeable weather in Shetland, with the incessant storms of wind

* 'Roy. Soc. Proc.,' A, vol. 101, p. 114 (1922).

† 'Roy. Soc. Proc.,' A, vol. 100, p. 367 (1922).

and rain, is very unfavourable to continuous observation. None of the photographs were equal in intensity to the photograph I obtained in the South of England of the world-wide aurora of May 14, 1921.

Those Shetland photographs which showed the green aurora line usually showed the nitrogen bands as well: but less strongly than the green line. In this respect the Shetland photographs stand between those of the world-wide aurora of May 13–14, 1921, and the ordinary night sky in the South of England.

Coming to the latter, the photographs discussed in the former paper* were somewhat faint, few if any of them being robust enough for satisfactory reproduction. It is a question of some importance to determine whether or not nitrogen bands are ordinarily present in the night sky, and for this purpose I made a cumulative exposure at Terling, Essex, with one of the spectrographs mentioned in the former paper (objective aperture F/1·9) for fifteen nights around the time of new moon. All the hours of darkness were utilised from November 21 to December 6, 1921, aggregating about 180 hours.

The green aurora line came up strongly, and besides this there was a faint solar spectrum, showing the band near G, and the H and K lines of calcium. As the moon was not below the horizon during the whole time of exposure, the possibility that this latter was due to moonlight is not excluded.

There was no trace on this plate of the nitrogen bands, and it is certain that their intensity cannot have been more than a very small fraction of the intensity of the green line. The plate used was an Imperial orthochromatic.

Another exposure was made on an Ilford panchromatic plate from December 23 to January 4 inclusive. It showed the green line but faintly, as might be expected from the poor sensitivity in this region. There was no trace of anything else. In particular, there was no solar spectrum, no nitrogen bands, and no trace of the red aurora line.

The search for nitrogen bands could scarcely be pushed much further with this instrument. Exposures have, however, been made with two instruments of much greater light gathering power, working at F/0·9. With these, strong impressions of the green line are sometimes obtained in one clear night: but in no case have the nitrogen bands been detected.

For satisfactory comparison with the Shetland photographs, it is necessary to have at least equal intensity in the green line: only so does the absence of nitrogen bands from the Terling photograph have definite significance. I

* 'Roy. Soc. Proc.,' A, vol. 100, p. 367 (1922).

have selected the more intense Terling photographs for comparison with Shetland, assigning intensities on a scale 1 to 5. It will be understood that if, *e.g.*, a Terling photograph is assigned a density 4 for the green line, the image of that line is actually of about the same density as that of a Shetland photograph marked 4.

It is difficult to give comparable figures for the Terling spectra of May 13–14, 1921 (the occasion of the great magnetic storm), because in this case the various groups of nitrogen bands had their second and third and even fourth heads developed, whereas the first heads were alone visible in the Shetland photographs. It will suffice to recall that the first head of the violet group λ 4278 and the head of the ultra-violet group 3914, each

Shetland Spectra.

Date.	Intensities.				Remarks.
	Green line. 5578.	Nitrogen.			
		Blue. 4709.	Violet. 4278.	Ultra-violet. 3914.	
January 16, 1922 ...	5	1	3	3	Somewhat masked by moonlight.
December 26, 1921 ...	4	0	2	2	
December 24, 1921 ...	3	0	1	1	
December 8, 1921 ...	2	0	1	1	
January 8, 1922 ...	2	0	1	3	
December 28, 1921 ...	2	0	1	2	
December 27, 1921 ...	2	0	0	0	
December 23, 1921 ...	1	0	0	0	

Terling Spectra.

Date.	Intensities.				Remarks.
	Green line. 5578.	Nitrogen.			
		Blue. 4709.	Violet. 4278.	Ultra-violet. 3914.	
Nov. 21–Dec. 6, 1921	5	0	0	0	Cumulative exposure, F/1·9 instrument.
February 17–20, 1922	5	0	0	0	Cumulative exposure, F/0·9 instrument.
February 6, 1922 ...	4	0	0	0	F/0·9.
Feb. 25–Mar. 3, 1922	4	0	0	0	Cumulative exposure, F/0·9.
March 6, 1922 ...	4	0	0	0	F/0·9.
March 8, 1922 ...	4	0	0	0	F/0·9.
March 9, 1922 ...	3	0	0	0	F/0·9.
February 17, 1922 ...	3	0	0	0	F/0·9.

had a somewhat greater photographic intensity than the green line. For further details the Table in 'Roy Soc. Proc.,' A, vol. 101, p. 116, 1922, may be consulted.

No direct comparison of intensity for equal exposure at Terling and Shetland can be given. The uncertain weather in Shetland makes it an unfavourable locality for examining the general light of the night sky, apart from the visually distinguishable aurora which is usually only seen low down in the north.

The comparison I am able to give is between the latter and the general light of the sky at Terling, and it deals only with the intensity of the nitrogen bands relative to the green line. The northern lights in Shetland have a much greater absolute intensity, but it is seldom that a long exposure upon them can be secured.

Calculation of a Primary Standard of Mutual Inductance of the Campbell Type and Comparison of it with the Similar N.P.L. Standard.

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(Communicated by Sir Joseph Petavel, F.R.S. Received February 4, 1922.)

(From the National Physical Laboratory.)

Introductory.

The standard mutual inductance devised and designed by Mr. A. Campbell and constructed in 1907–8* at the National Physical Laboratory has been one of the foundations of our alternating current measurements since that date.

It will be sufficient here to note that the special feature in the design of the Campbell type of mutual inductance consists in a primary single-layer winding, so proportioned that the field due to it is practically zero over the region occupied by the secondary coil. By this means the dimensions of the secondary coil are rendered relatively unimportant, so that it may be an overwound many-layer winding, whereby a suitably large value of mutual inductance may be obtained.

* A. Campbell, 'Roy. Soc. Proc.,' A, vol. 79, p. 428 (1907).